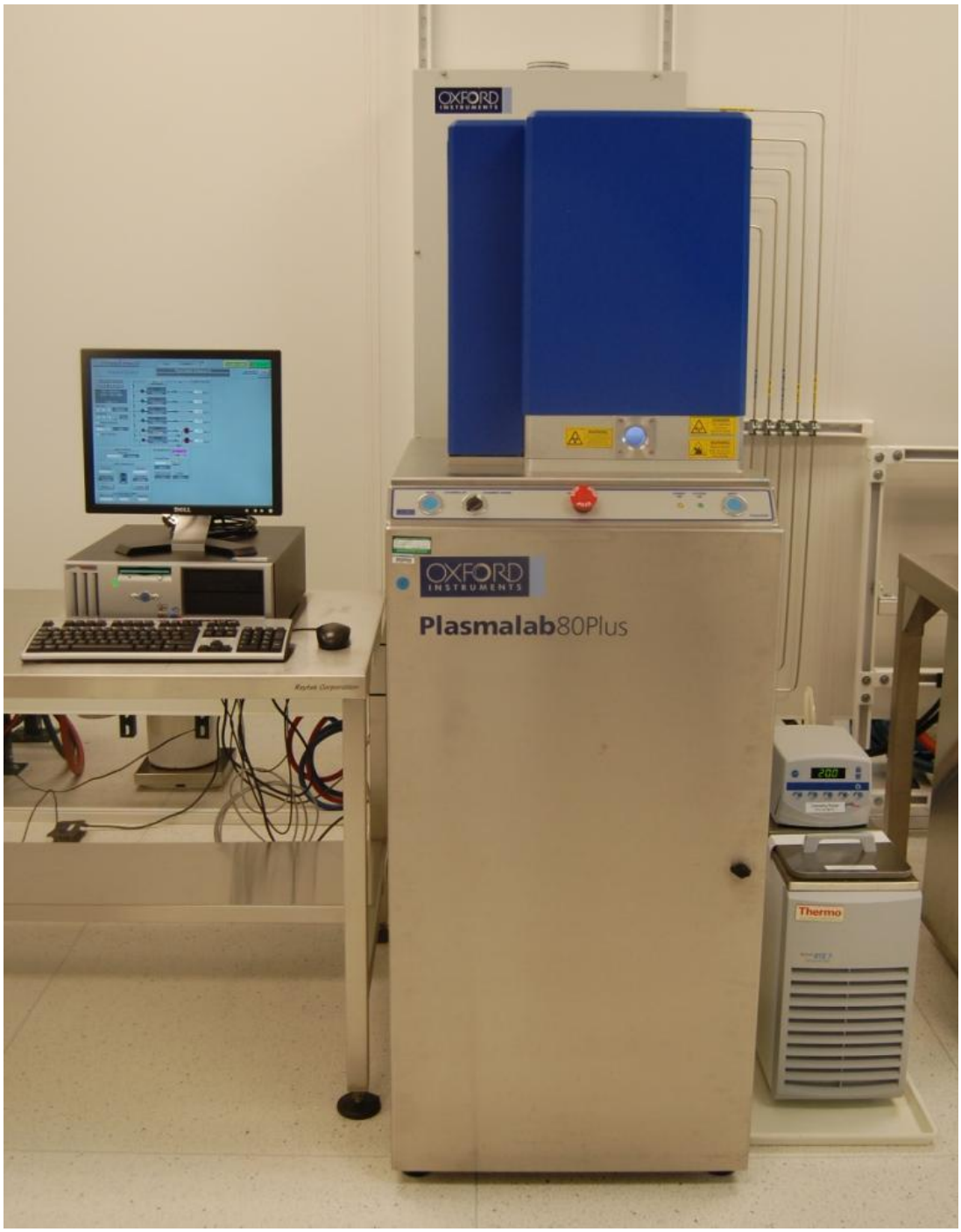
Center for Integrated Nano-Technologies

Oxford PlasmaLab80 Fluorine Reactive Ion Etch System



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1. PURPOSE

This document provides the necessary information for the safe use of the Capacitive Coupled Plasma Reactive Ion Etch system located in the Integration Lab (Room 1530) at Center for Integrated Nano-Technologies (Bldg 518). Any questions beyond the scope of this document should be directed at the Key Operator.

2. ACRONYMS

Many pieces of equipment and procedures are known almost exclusively by their associated acronym, it is important to become familiar with the following list to avoid confusion.

SNL- Sandia National Labs
CINT- Center for Integrated Nano-Technologies
SOP/OP- Standard Operating Procedure/Operating Procedure
LEL – Lower Explosive Limit
PEL – Permissible Exposure Limit
LCD – Liquid Crystal Display
RF – Radio Frequency
RIE – Reactive Ion Etch
ES&H – Environmental Safety and Health
S&S- Safeguards and Security
QA- Quality Assurance
PM- Preventative Maintenance
UV- Ultra Violet
HV- High Voltage

3. DEFINITIONS

Authorized User- Personnel with the required training and subsequent approval of the Integration Lab manager to use said equipment.
Key Operator- Key Operators are qualified to perform tool specific training of Authorized Users, and are responsible for the maintenance of the equipment.
Delegated Representative - Individual who is delegated by the Integration Lab Manager or Key Operator to assist with specific training. The individual must have demonstrated competency in the specific activity before becoming a delegate.
Visitor- Personnel trained in the cleanroom overall safety and gowning procedures, but not authorized to operate equipment.
ES&H Officer – Provides ES&H, S&S, and QA for CINT activities.

4. RESPONSIBILITES

It is the responsibility of every employee, contractor, and visitor to ensure a safe and healthy working environment. There is no experiment or procedure at Sandia that is so urgent that it needs to be done in an unsafe manner, and it is everyone's obligation to refuse to do work that he or she believes to be unsafe. If there is an activity or situation that is of concern it is their immediate responsibility to contact a supervisor or ES&H representative.

5. TRAINING

Prior to using any Integration Lab tools it is necessary to complete the general, site, and tool specific training. The training required for the operation of RIE1 is listed below.

5.1 Corporate Level General training

CINT personnel shall complete the following Corporate-required training courses prior to using the RIE. This list may not be inclusive, so refer to the training section of the PHS associated with the RIE for additional information.

- ESH100 - Laboratory Standard Information and Training
- CHM100 - Site Specific Laboratory Safety Training
- PSO – Pressure System Operator Qualifications Form
- ENV112 - Hazardous Waste and Environmental Management Training

5.2 Site Specific training

In addition to corporate-level training, site specific training shall be completed. These courses are administered through either the Integration Lab Manager or a delegated representative.

- ILUA100 - Site Specific Training for Unescorted access to the Integration Lab
- Site Specific Training for Personal Protective Equipment
- Site Specific Training for Chemical Handling

5.3 Tool Specific training

Once all corporate and site specific training has been completed, the user must schedule a walk through and training session with the Tool's Key Operator or a delegated representative. The user may contact the Key Operator or training coordinator for scheduling.

6. APPROVAL, NOTIFICATIONS, SCHEDULING

After reading and signing all applicable OP's, finishing all associated training including hands on training from the Key Operator or a delegated representative the user will be free to use the tool as needed. The authorized user will then be given access to schedule the tool in the on-line tool calendar located at: www.google.com/calendar .

Tool ID is Email: cintrie1 Password: 1530rie1

7. SAFETY PRECAUTIONS AND LIMITATIONS

This section describes hazards identified with the RIE system and the actions taken to alleviate those hazards. The hazards are contained by the design features provided by the manufacturer and are insured by proper operating procedures.

There are several major hazards to personnel:

- Thermal Hazards
- Electrical Shock
- Compressed Gas Hazards
- UV Burn Hazard/ UV-Light or Non-Ionizing Radiation Exposure
- Mechanical pinch hazards

During normal operation, the CINT RIE system is an inherently safe tool and has limited possibility of exposure to hazards. Only the Key Operator or IL maintenance personnel may remove the tool's protective covers or perform maintenance.

Under no circumstances are system modifications, configuration adjustments or process chemistry changes (new gasses) allowed without obtaining the necessary approvals from the Key Operator and Integration Lab Manager. Once approved, all modifications to the system are to only be performed by Integration Lab personnel or the equipment manufacturer's representative.

7.1 Thermal Hazards

Internal surfaces of the system and the substrates may become heated during operation to temperatures. Substrates must be handled with tweezers or vacuum wands. The exterior of the equipment does not become hot.

7.2 Electrical Shock

Electrical hazards are present in the RIE system. There is a potential for producing lethal electrical shocks as well as the potential for electrical arcing and fire. These hazards are contained by multiple levels of interlocks, shielding, and controls. If the system requires maintenance or troubleshooting where the exterior panels are removed, proper lockout/tag-out procedures must be followed.

Power supplies are used to power electronics, create plasmas, and operate mechanical pumps. Failure to follow recommended electrical safety precautions (all high voltage sources marked clearly, proper grounding straps, shielded device connections, and no frayed cords) could result in severe injury or death. Any electrical troubleshooting of the system must be done by qualified personnel as authorized by CINT management and according to safe procedures when working with high voltages. High voltage electrical repairs will not be performed alone. Only trained personnel as authorized by CINT management are permitted access to the service areas of the RIE system. Servicing of the system will take place only when two people are present.

The remaining high voltage or high current power supplies employ shielding to prevent contact with dangerous regions of the supply without first removing the shields. Before removing the outside protective panels, disconnect the appropriate circuit breaker on the main power distribution panel.

The RIE system is equipped with an Emergency Power Off switch. All valves on the system are of the normally closed type, meaning that if the power is suddenly lost, all valves will close and no gases will enter the chamber or atmosphere.

7.3 Compressed Gas Hazards

Several gases can be used with the RIE system. These gases include but are not limited to the following: Argon, Oxygen, Sulfur Hexafluoride, and fluorocarbon etch gases. The facility gas panels or cabinets are equipped with pressure relief valves or pressure sensors as specified by Sandia safety procedures.

High purity nitrogen is used to vent (bring to atmospheric pressure) all segments of the system. The stainless steel reaction and load chambers are self relieving and do no present an immediate safety hazard. Control measures for over-pressurization of the system are the chamber lids that release when the pressure reaches atmosphere.

Handling and storage procedures for compressed gases are presented in the ES&H Manual. Familiarity with these procedures minimizes the possibility of accidental releases of toxic gases and exposure of personnel to harmful levels of these gases.

7.4 Chemical Gas Hazards

Chemical substances may be present in the RIE chamber in the form of etch or deposition byproducts. Chemical substances from these processes are found as absorbed residue on the vacuum chamber walls and etched substrates. These chemical substances are contained within the vacuum chamber walls and etched substrates. These chemical substances are contained within the vacuum chamber during operation. RIE user's must be protected against skin contact with the chamber walls and etched and deposited wafers and therefore must wear cleanroom gloves and use tweezers or vacuum wands when handling the wafers. Maintenance personnel and authorized users must wear appropriate person protective equipment when working on surfaces exposed to the plasma. When working with the RIE, gloves and safety glasses must be worn.

All etch and deposition byproducts or fluids generated by or used to maintain the RIE reactor must be considered hazardous and handled according to the standards west by Sandia ES&H.

Fluids used in the pump package (Fomblin) of the RIE system may be hazardous. The vacuum pumps operate in environments contaminated by potentially toxic compounds and etch and deposition byproducts. These toxic substances may be absorbed through the skin; therefore personal protective equipment must be used when handling the fluids. The fluids are of the PFPE-type and can be reclaimed by returning the used portion to the distributor in accordance with the shipping procedures outlined by the distributor.

7.5 Mechanical pinch hazards

Any equipment that has moving parts will have some sort of pinch hazard. The RIE system has several moving pieces. It is important to be alert when working near moving parts.

7.6 Gas Release Hazard

The system is equipped with interlocks which prevent the flow of process gas without adequate vacuum. The vent option is only available when the process gas flows are off. Provisions are also included in the operation procedures that a pump-purge cycle be used following each process.

7.7 Non-Ionizing Radiation Hazards

Radiation hazards present with the RIE systems are:

a) Radio-frequency energy 13.56MHz at 300W is capable of producing burns or other tissue damage.
b) Exposure to UV light from the optical emission of plasma.

System design controls radiation leakage outside the vacuum system. UV light may be produced by the plasma, it is important to minimize escape of UV light from the system, and wear protective eye wear when appropriate. Prolonged exposure to UV light can cause inflammation of the cornea and can induce cataracts.

8. SPECIAL TOOLS, EQUIPMENT, PARTS, AND SUPPLIES

- Tweezers for loading or unloading samples.

9. SYSTEM OPERATING AND MAINTENANCE PROCEDURES

Operation of the RIE system is to be performed by trained and authorized personnel. Normal operation of the RIE system is performed following the procedures outlined in this document and in the RIE system Instruction Manual. Since the RIE system is protected by interlocks and protective fastener-secured panels, it can be operated by an authorized user without additional observation.

9.1 Set-Up and Preparation

Upon arrival the RIE should be in standby mode and a dummy wafer should be present on the electrode in the reaction chamber. There is no test or activity at Sandia so urgent that it needs to be done in an unsafe manner, and it is an employee's obligation to refuse to do work that he or she believes to be unsafe. Matters of this nature will be resolved to the employee's satisfaction before the work proceeds.

Verify the following before attempting to run a process:

- Vacuum – Verify that the reaction chamber pressure pumps below 1 mT *(see Pump Control menu section 9.2)*. If the reaction chamber pressure level is above 1 mT at base pressure, contact the Key Operator.

- Lower Electrode Heat Exchanger - Verify that the lower electrode heat exchanger is turned on and that no alarms are present *located on the floor to the right side of system mainframe)*. Powered electrode temperature will vary by chemistry however as a rule the RIE should be around 20°C. To prevent system damage the chiller temperate should not be operated below 10°C or above 50°C. Contact the Key Operator if a problem is detected in this area.

- Equipment Cooling Water – A house process chilled water system provides cooling for the RF generator, turbo molecular and process mechanical pumps *(see Pump Control menu section 9.2)*. If the system alarms for water flow notify the Key Operator before operating.

9.2 Operational Procedure

Operating Screens

- **System – (System Menu) Pumping**: Pump Control menu. View interlock status, process chamber pressure vacuum pump and valve status. Provides accesses to pump down and vent controls.
- **System – (System Menu) System Log**: System event logging, macro view that does not include run specific information.
- **System – (System Menu) Password:** cint / cint
- **Process – (Process Menu) Recipes:** Contains step library and recipe information. Provides the interface to simply select and run and an existing recipe or build a new recipe from step library components.
- **Process – Chamber 1:** Process view, provides a global view of real time process conditions that includes chamber pressure, gas flow rate, RF power and dc bias level and step time.

System Operation

Load/Unload Sample

1) Vent Process Chamber
    a. Select <System> (System Menu), then <Pumping> to enter the pump control menu.
    b. Select <Stop> to halt any active pump or vent operation. Chamber status will change to "Pumping or Venting Stopped".
    c. Select <Vent> to vent the process chamber, chamber status changes to" Vent Start". Watch "Vent Time Left" clock to determine vent status.
    d. "Gas Pod Interlock" indicator color will change from "green" to "red" when the chamber reaches atmosphere. An over vent of 120 second will continue, the chamber can be opened at any time once the chamber reaches atmosphere.

2) Place Sample on Lower Electrode
    a. Chamber must be at atmosphere.
    b. On the front panel of the reactor mainframe, move the "Chamber Up/Chamber Down" switch to the "Chamber Up" position.
    c. Note – When system sits for long period of time, lid will pop when opened, do not be alarmed. Simultaneously press both "Hoist" buttons continue to hold until the lid has completely rotated 90 degrees (CCW) away from the lower electrode.
    d. Place sample on to or remove from the lower electrode.
    e. Move the "Chamber Up/Chamber Down" switch to the "Chamber Down" position.
    f. Simultaneously press both "Hoist" buttons simultaneously and continue to hold until the lid has completely rotated 90 degrees (CW) towards the lower electrode. Allow the open and lower chamber halves to make contact before releasing.

3) Evacuate Process Chamber
    a. Select <System> (System Menu), them <Pumping> to enter the pump control menu.
    b. Select <Stop> to halt any active pump or vent operation. Chamber status will change to "Pumping or Venting Stopped".
    c. Select <Evacuate> to pump the process chamber.

    d. When prompted to "load wafer – (OK)" or "pump chamber-(Cancel)" select "OK". Chamber status changes to "Evacuating Chamber". Be patient, it takes several seconds for the evacuation process to initiate.
    e. Watch "CM and Penning" gauges to determine process chamber pressure status.
    f. "Gas Pod Interlock" indicator color will change from "red" to "green" when the chamber reaches a safe pressure level.

Select, Run or Change Process Parameters

1) Select Recipe
    a. Select <Process> (Process System Menu), then <Recipes> to enter the Recipes menu.
    b. Select <Load> and when prompted to "Overwrite Current Recipe" select <Yes>.
    c. "Load Recipe" will display, select the desired recipe from the list and press <OK>.
    d. The selected recipe should appear in the "Recipe Name" window at the top of the screen.

2) Adjust Recipe Time
    a. The recipe consists of a series of steps beginning with a "pump-purge" sequence (steps 1, 2 and 3), main etch (step 4) and then ending with a "pump-purge" sequence (steps 5, 6 and 7).
    b. Highlight the main etch step, a "Step Commands" window will appear. If necessary select <Cancel> to exit.
    c. Select <Edit Step>.
    d. Adjust <Step Time> for the desired etch time. Please note that the format is HH:MM:SS.
    e. Press <OK> when finished editing the step time.

3) Change Process Parameters – DO NOT ADJUST PUMP-PURGE STEP PARAMETERS
    a. Select recipe as described above, this will serve as the template to create the new recipe.
    b. Change "Recipe Name" to something other than what is displayed. Failure to rename the recipe may cause the original recipe to be overwritten.
    c. Select <Save> to save the new recipe.
    d. The recipe consists of a series of steps beginning with a "pump-purge" sequence (steps 1, 2 and 3), main etch (step 4) and then ending with a "pump-purge" sequence (steps 5, 6 and 7).
    e. Highlight the main etch step, a "Step Commands" window will appear. If necessary select <Cancel> to exit.
    f. Select <Edit Step>.
    g. Adjust process parameters accordingly.
    h. Press <OK> when finished editing the process step.
    i. Select <Save> to save recipe changes.

4) Run Process
    a. Process run can be initiated from either the "Recipes" screen - <Process> (Process Menu), <Recipes> or "Chamber 1" (Process Control) screen - <Process> (Process Menu), <Chamber 1>.
    b. In the "Recipes" screen select <Run> to initiate the process. Once the process has initiated the "Chamber 1" status window will appear.
    c. If necessary to manipulate a running process, use the "Process Screen", accessed through <Process> (Process Menu), <Chamber 1>, to <Start> start the process, <Pause> to pause/resume the current step, <Stop> to stop the process or <Jump> to end the current step.
    d. Once the process has finished, a "Yellow Alert" will display indicating that the process is complete, Acknowledge or <Accept> this alert message. The system will automatically vent when the process recipe is complete.
    e. Evacuate chamber after removing sample.

9.3 Shutdown/Start-up

1. Emergency Shutdown – Press the Emergency Stop Switch located on the front of the system console. Notify Key Operator.
2. System Startup
    a. If amber power on light is light, press the green <On> button that is located behind the front door of the system console. Green system on light should light.
    b. Turn on system computer and monitor.
    c. When prompter to log onto Windows, press <control-alt-delete> to begin. User name: Administrator, password – just press <OK>.
    d. When windows desktop appears, launch the "PC 2000 – OPT" application.
    e. Access control screen will appear, "Enter Name" = cint, "Enter Password" = cint
    f. Pump control screen will appear, click on the vacuum pump icon to turn on the process mechanical pump. Once the pump starts, the "evacuate" or "stop" buttons can be selected.
    g. Select <evacuate>, and when prompted to "Load wafer or pump chamber" select <OK>. After a short delay, the turbo will begin accelerating.
    h. Once the turbo is "at speed" and the chamber reaches base pressure the tool is ready to use.
3. Controlled Shutdown
    a. Select <System> (System Menu), then <Pumping> to enter the pump control menu.
    b. Select <Stop All Auto Processes>, button is located in top right hand corner of "Pump Control" screen. Follow instructions when prompted.
        a. "Automatic Process Shutdown" screen will appear asking if you want to shut the entire system down. Select <Yes>.
        b. "System Shutdown" screen will appear instructing you to shut down system. Press <OK>.
        c. "Restart" screen will appear, acknowledge that you have read the message by pressing <Yes>.
    c. Shut down the Windows computer.
    d. Power down system by pressing the red <Off> button that is located behind the front door of the system console.
    e. System is now powered down.

9.4 Maintenance

System maintenance is not covered in this procedure. If tool's status indicator is "Green" with arrow up, the system is available for use. If the status indicator is "Red" with arrow down, the system is down, contact the Key Operator or IL maintenance personnel to inquire about tool's status.

10. SIGNATURE OF COMPLETION

By my signature below, I affirm that I:
• Have read and understand this operating procedure (OP) entitled *Operating Procedure for the Oxford PlasmaLab80 Reactive Ion Etch System.*
• Have read and understand the PHS/HA for this laboratory and signed signature page
• Will take the required training before working with this equipment.

Name (Printed)	Signature	Org	Date